BIOLOGICAL EVALUATION OF GYPSY MOTH

at

BLACKWATER NATIONAL WILDLIFE REFUGE

Part of the
Chesapeake Marshlands National Wildlife Refuge Complex

Prepared by

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Abstract

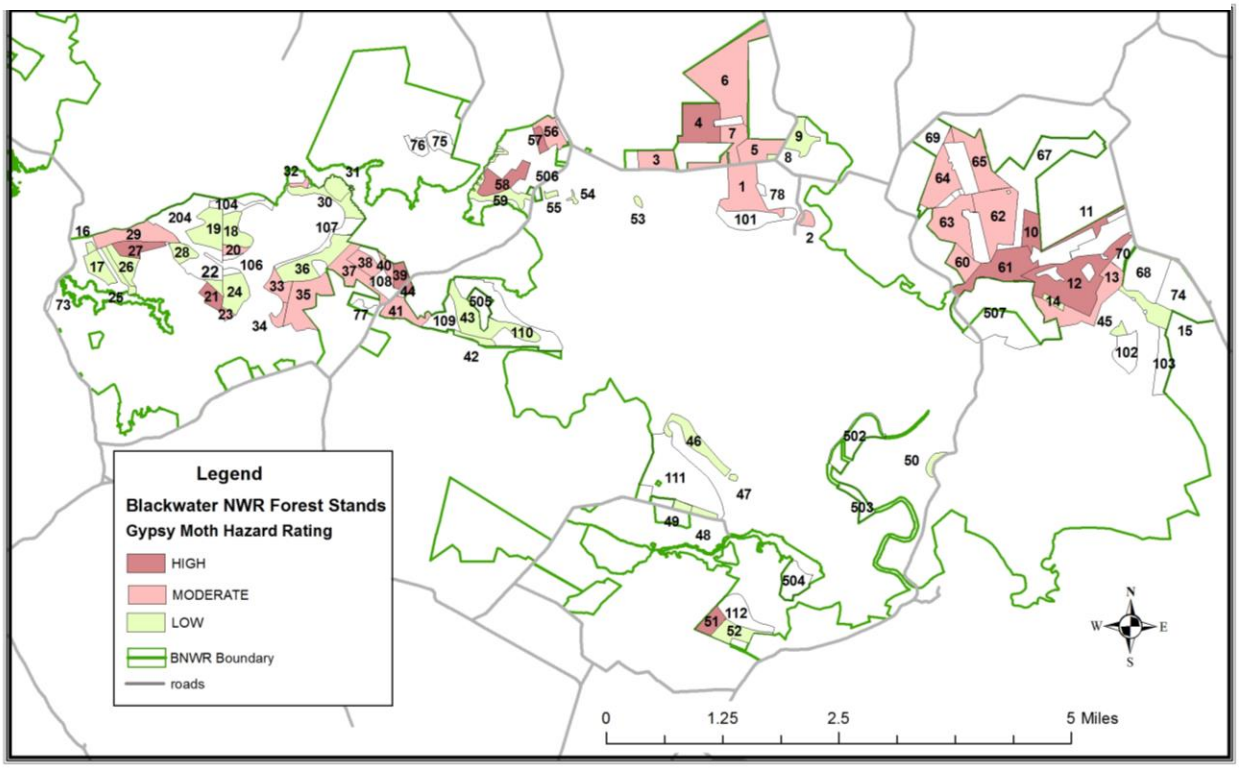
In June 2014, the Blackwater National Wildlife Refuge (BNWR), which is part of the Chesapeake Marshland National Wildlife Refuge Complex (CMNWRC) in Maryland, experienced gypsy moth defoliation on approximately 256 acres in the Kentuck Swamp area of the refuge. In April 2015, a total of 250 acres were treated with a single application of Gypchek at 4 x 10^{11} OB's, since population densities were under 500 gypsy moth (GM) egg masses (EM) per acre. Foliage protection in the treatment block was achieved. In August 2015, USDA Forest Service personnel conducted a gypsy moth egg mass survey at BNWR to assess the potential for defoliation and the need for treatment in 2016. Current populations are still sufficient to cause noticeable defoliation on approximately 500 acres. Retreatment is recommended in 2016 in order to protect the endangered Delmarva fox squirrel habitat from tree defoliation, prevent a reduction in oak mast production, provide nuisance abatement in the Key Wallace Hiking Trail area, and prevent possible oak tree mortality.

History

The USDA Forest Service (USFS), Morgantown Field Office (MFO) has had a long relationship with BNWR over the last 23 years. There have been 11 gypsy moth (GM) spray projects from 1993 – 2015. A total of 7, 736 acres were treated with *Bacillus thuringienis* variety *kurstaki* (*Btk*) and a total of 5,519 acres were treated with Gypchek during that time.

A report written by Rod Whiteman and Brad Onken, assigned forest stands at BNWR with a gypsy moth hazard rating. When gypsy moth infestations build up, this hazard rating can help provide focus on where to conduct gypsy moth surveys (Figure 1).

Figure 1. *Assigned gypsy moth hazard rating for forest stands at Blackwater NWR in Dorchester County, MD. (Whiteman and Onken. 1994)*



On April 23, 2015, a total of 500 acres at Blackwater National Wildlife Refuge (BNWR) were aerially treated to prevent defoliation. A single application of the biological insecticide Gypchek was applied at the rate of 4 x 10^{11} occlusion bodies per acre in a total formulation of 1 gallon per acre. A Bell OH-58 helicopter equipped with a Differential Global Positioning System (DGPS), AGNAV, was used to apply the insecticide (Figure 2).

Figure 2. *Helicopter application of gypchek at BNWR, April 2015.*

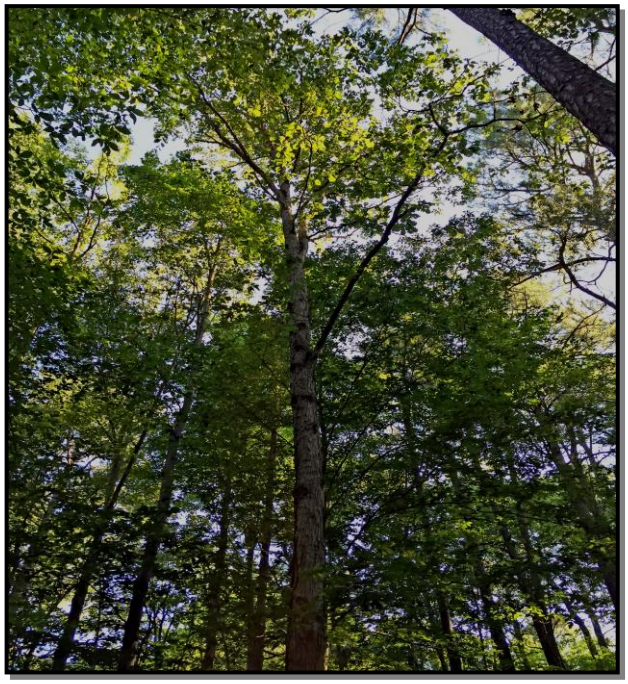


Figure 3. *Foliage protection provided by single application of gypchek at BNWR, 2015.*

The treatment timing was based on the larval and foliage development and meteorological conditions inside the block, and all conditions were within acceptable limits (Reardon et al. 2012). Based on observations made by USDA Forest Service personnel in the treatment block and by viewing the AGNAV system, spray coverage was good through the entire application. There were no unacceptable skips in the treatment block.

In June 2015, personnel from the USFS, Forest Health Group, Morgantown, WV Field Office (MFO), conducted from the ground a defoliation detection survey within the 2015 gypsy moth spray block at the BNWR. An average estimate of the oak defoliation within the view from each plot center was recorded. Most survey locations, were determined to have very light, very scattered defoliation and not noticeable to the casual observer. This level of defoliation/damage does not cause significant stress to the oak trees (Figure 3). Also detected were GM caterpillars killed by the Nucleopolyhedrosis virus (NPV, Gypchek) and *Entomophaga maimaiga* fungus. The NPV occurring naturally in nature does not kill as quickly as the fungus, so its affects are usually masked by the presence of the fungus. Forest stands with both the virus and fungus occurring naturally will still experience defoliation, since caterpillars are not affected until later instars, after defoliation has already occurred. Knowing this, the application of Gypchek, which normally affects the caterpillars with 10-14 days after ingestion, indicates that the treatment provided foliage protection, otherwise there would have been defoliation in the block, especially with the current GM population density.

We also utilized the US Forest Service, Forest Health Technology Enterprise Team (FHTET) Forest Disturbance Monitor (FDM) website (http://foresthealth.fs.usda.gov/portal/Flex/FDM?dL=0) to detect

any areas of forest canopy disturbance that were occurring elsewhere on the Refuge. There were no areas of significant disturbance detected in June/July 2015 on BNWR property.

Methods

Gypsy moth survey plots were randomly selected based upon available host trees (oak species) in the 2015 treatment area.

At each sample point, a 1/40th acre fixed radius plot was established. An inspection of all egg masses within reach was used to estimate the portion of new (2014) to old egg masses at each plot (percent new egg masses). This percentage was applied to the tally of all egg masses observed above the reachable surface. The plots consisted of a tally of all new egg masses observed on overstory trees, understory vegetation, ground litter and duff. The total number of new egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre (Leibhold et al. 1994).

Defoliation predictions for 2016 are based on the egg mass density, threshold, egg mass length, population trends, and species composition (Liebhold et al. 1994, Leibhold et al. 1993; Table 1). Intervention thresholds were established on resource management objectives and nuisance abatement, and the prevention of defoliation (Table 1).

Table 1. *2015 Gypsy moth egg mass density thresholds for resource management objectives on the Blackwater National Wildlife Refuge, MD.*

Threshold (egg masses/acres)	Predicted Defoliation	Objectives
250	< 30[1] %	Nuisance Abatement
251-500	30 - 40 % (Light)	Prevent Noticeable Defoliation
501-1000	41 - 60 % (Moderate)	Prevent Growth Loss
>1000	> 60 % (Heavy)	Prevent Mortality

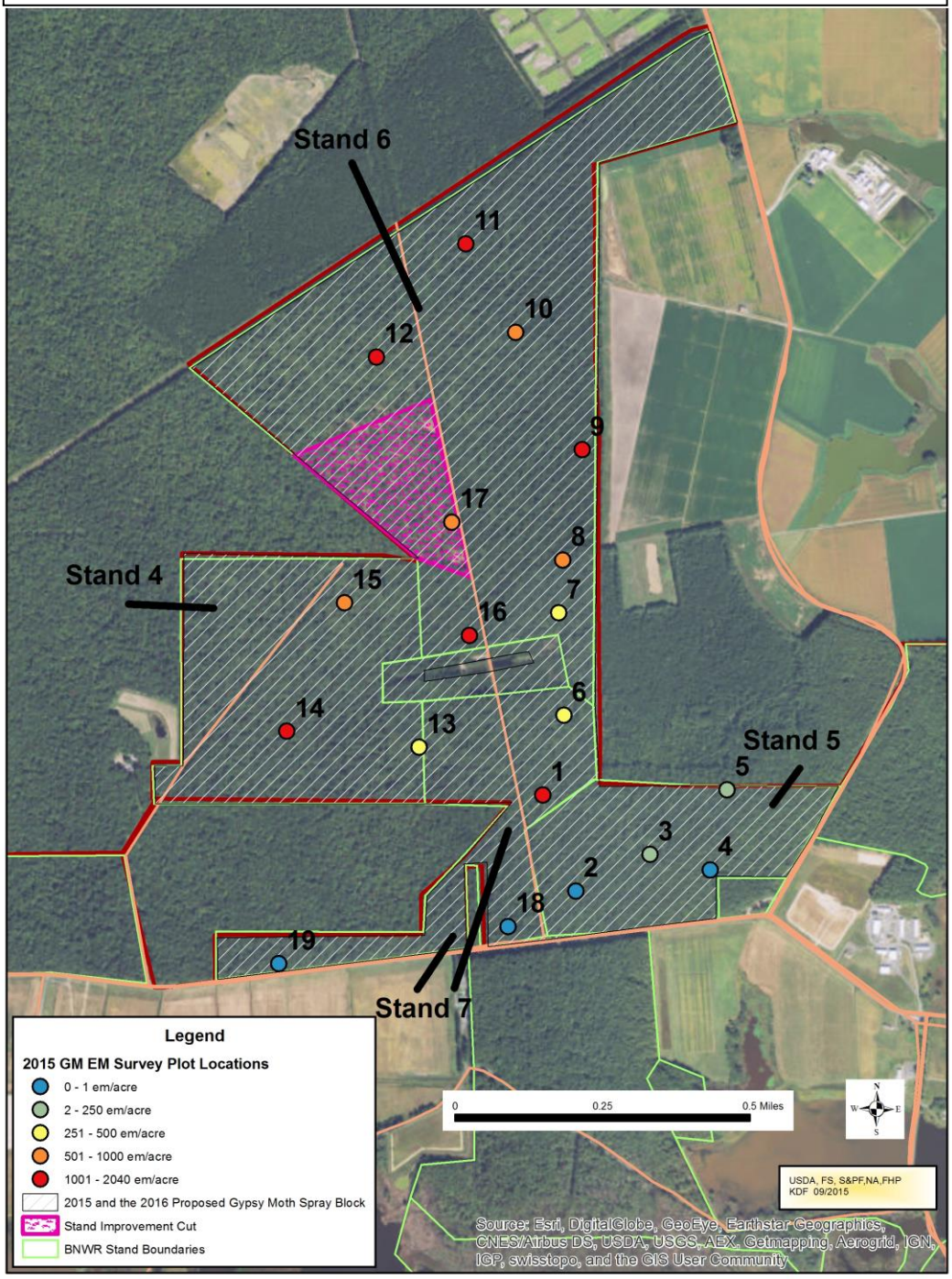
[1] None or background level of defoliation.

Egg mass length was measured at most of the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity. Small egg masses (<20 mm in length) are indicative of a declining population, while large egg masses (>30 mm in length) of an increasing population (Liebhold et al. 1994). The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) are used to estimate defoliation potential (Liebhold et al., 1993).

Results

The locations of the survey plots are shown in Figure 4.

Figure 4. *2015 gypsy moth egg mass survey plot locations and the 2016 proposed treatment block (500 acres- 2 applications of Gypchek) at Blackwater National Wildlife Refuge (CMNWRC) – Maryland.*



Egg mass densities per acre throughout the surveyed areas (2015 treatment area) at BNWR ranged from 0-2040 and averaged 714 egg masses per acre. Overall average egg mass lengths ranged from 23-36 mm and averaged 30 mm. Gypsy moth population densities are high enough to cause light to moderate defoliation within portions of the block (Figure 4). Even though the foliage was protected from defoliation in the spray block in 2015, populations have become more evenly spread out and the new areas have higher population densities than in 2014 (over 200% increase overall).

The crew also took a look at BNWR property within the vicinity of the spray block and no GM egg masses were observed in these adjacent areas. The Refuge personnel also report that nothing of significance was noticed elsewhere on the Refuge.

Defoliation prediction is further supported by using egg density as a means of estimating gypsy moth population densities. Moore and Jones (1987) found that estimating the mean fecundity would increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. The average egg mass density of 714 egg masses per acre x 30 mm (average egg mass length) translates to a projected defoliation level of about 35 percent (moderate defoliation). This represents an overall average and since egg mass densities and host type are not evenly distributed, actual defoliation will vary somewhat from tree to tree throughout the area.

The summarized results of the survey are presented in Table 2.

Table 2. *2015 Gypsy moth egg mass survey results, predicted defoliation, and special concerns for surveyed stands at the Blackwater National Wildlife Refuge, MD.*

Stand Number	**Gypsy Moth Hazard Rating**	**Average Egg Masses per Acre**	**EM Density Predicted Defoliation (%)**	**Liebhold et al. GM EM Size and Density Predicted Defoliation (%)**	**Special concerns regarding 2016 gypsy moth defoliation** All stands Delmarva fox squirrel habitat
4	High	540	41 - 60 %	32%	High oak component
5	Moderate	54	< 30 %	< 10 %	Key Wallace Hiking Trail and Demonstration Forest
6	Moderate	1220	> 60 %	42%	Oak improvement cut, Key Wallace Hiking and Demonstration Forest
7	Moderate	340	30 - 40 %	26%	Key Wallace Hiking Trail and Demonstration Forest
Stands 4-7	-	714	41 - 60 %	35%	All concerns

Discussion

The survey results indicate that noticeable defoliation (light to moderate) is likely to occur on approximately 500 acres in stands 4-7 (Figure 4). Since egg mass densities and host type are not evenly distributed, actual defoliation will vary somewhat from tree to tree throughout stands 4-7. Even though stand 5 has low gypsy moth egg masses counts, it could still experience some noticeable defoliation and stand 5 does contain the Key Wallace Hiking Trail and Demonstration Forest, therefor it has been included in the 500 acres in order to meet the objective of nuisance abatement.

At BNWR the average egg mass length is 30 mm indicating a stable to increasing population, but both the fungus and virus were observed in these stands in 2015 and it is possible that either could cause a general collapse next year if wet weather conditions occur in the spring of 2016. However, a population collapse is not likely to occur prior to a defoliation event in 2016.

Since defoliation reduces the trees ability for future photosynthesis and re-foliation events causes the tree to expend carbohydrate reserves, these factors that must be considered when deciding whether intervention is necessary or warranted. Other factors that need to be considered are the condition of the trees at the time of defoliation (i.e. stand stocking, age and amount of susceptible species present). Studies have shown (Gottschalk 1989), that reduced growth, mast abortion, branch dieback or in some cases tree mortality, has been observed following a single year of heavy defoliation. Should a subsequent period of drought or other stressors occur during a defoliation event or even after, the potential impact on individual trees may be compounded

Management Options

For 2016, two management options have been evaluated for managing gypsy moth populations at BNWR. The intervention option is offered based upon the following two treatment objectives: 1) for nuisance abatement of gypsy moth population in high value recreation areas and 2) protect host tree foliage to prevent branch dieback, mast production failure, and tree mortality; thus providing Delmarva fox squirrel habitat protection. Each option is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the fungal pathogen, *E. maimaiga.* In areas with defoliating levels of gypsy moth populations (greater than 500 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels. Although it is not possible to accurately assess such events with information at hand, it is unlikely that a collapse will occur prior to defoliation.

Should this option be selected, it is likely that noticeable defoliation will occur in stands 4-7 at BWNR in 2016. There is also the potential for population densities to increase in infested stands and expand to currently un-infested areas in 2016.

Microbial Insecticide Option

***Btk*:** The second option is to use microbial insecticides to manage gypsy moth populations. Only one biological insecticide is currently registered and commercially available for gypsy moth control. It is the microbial insecticide, *Bacillus thuringiensis* variety *kurstaki* (*Btk*). *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis, which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* has been shown to impact other non-target caterpillars that are exposed to the treatment when actively feeding. *Btk* is persistent on foliage for about 7-10 days.

Btk is not specific and may reduce populations of short term non-target lepidoptera larvae that may be feeding at the same time as gypsy moth caterpillars. Several factors must be taken into account when using *Btk* such as: 1) the potential for short term non-target extirpation in the proposed spray area; 2) the life stage present and any deferential susceptibility to *Btk* that may exist between species of non-target lepidoptera; 3) the size and uniqueness of the area beginning proposed for treatment. Since much of this site-specific data regarding non-target lepidoptera may not be known for many areas, the potential benefits must be weighed against any potential impacts to non-targets.

Btk formulations are available as a flowable concentrate. The normal application rates range from 24-38 Cabbage Looper Units (CLU's) per acre in a single application for a total volume of ½ to ¾ gallon per acre. Double applications may be used in areas of healthy building populations where the egg mass densities may exceed 3,000 egg masses per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application. Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product (CLU's).

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it can be difficult to project treatment efficacy with less than optimal conditions following treatment. Most often foliage protection is achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 2 x 10^{11} occlusion bodies (OB's) per acre applied in two applications, or a single application at 4 x 10^{11} OB's. When supplies are limited, priority is given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments. There will be an adequate supply of Gypchek available for use at BNWR in 2015.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1 - No action

Alternative 2 - One aerial application of *Btk* at the rate of 24-38 CLUs in a total mix of ½ to ¾ gallon per acre.

Alternative 4 - One aerial application of Gypchek at the rate of 4 x 10^{11} OB's in a total mix of 1 gallon per acre.

Alternative 5 - Two aerial applications of Gypchek at the rate of 2 x 10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

Recommendations

As previously stated, gypsy moth populations are sufficient to cause noticeable defoliation (light to moderate) in stands 4-7 at BNWR. The area is the location of the Key Wallace Hiking Trail and Demonstration Forest and the Refuge has invested in a stand improvement cut to promote oak mast production for the habitat of the endangered Delmarva fox squirrel in stand 6. Taking all of this into account, our recommendation is Alternative 5, a double aerial application of Gypchek to stands 4-7, totaling 500 acres; in order to help protect tree foliage, prevent possible mast production failure, provide nuisance abatement on the Key Wallace Hiking Trail and prevent possible tree mortality.

The recommendation is further supported by the fact that the BNWR insecticide of choice is Gypchek. A double application of Gypchek will likely provide adequate foliage protection and provide some degree of population reduction, and possibly reduce the need for retreatment. Gypchek is host specific which minimizes the risk to other non-target organisms including lepidopteran caterpillars.

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